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Interim Report

ORSER-SSEL Technical Report 21-73

INVESTIGATION OF VEGETATIVE COVER CONDITIONS

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ERTS Investigation 082
Contract Number NAS 5-23133

INTERDISCIPLINARY APPLICATION AND INTERPRETATION OF ERTS DATA WITHIN THE SUSQUEHANNA RIVER BASIN

Resource Inventory, Land Use, and Pollution

(E73-11111) INVESTIGATION OF VEGETATIVE COVER CONDITIONS Interim Report (Pennsylvania State Univ.) 15 p HC $3.00 CSCL 08F
N73-33268
Unclas
G3/13 01111

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Date: May 1973

INVESTIGATION OF VEGETATIVE COVER CONDITIONS

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Vegetative cover conditions of two areas of northwestern Pennsylvania are under investigation. The first is in the vicinity of the southern branch of the Allegheny Reservoir (the "Kinzua" area) in the Allegheny National Forest in Warren County; specifically, it is the area immediately adjacent to the western side of the reservoir. The second is in the vicinity of the reservoir on the East Branch of the Clarion River (the "East Branch" area) in Elk County, particularly to the south and east of the reservoir. Both areas are heavily forested with open patches of vegetation throughout. The Kinzua test site is situated completely within the Allegheny National Forest while the East Branch test site presents an interesting combination of private land, state forest, and state game lands meeting near the base of the dam, permitting close comparison of land use patterns. Location of both sites on ERTS-1 images is facilitated by the presence of reservoirs and streams. The initial goals were to distinguish between forest and open vegetative areas; and within the open areas, to distinguish between herbaceous vegetation, scrub, and small saplings. It was anticipated that these distinctions would lead to mapping of various game cover types and estimations of carrying capacities for different game species in a given area. They would also be useful in evaluating land use changes over a period of time by comparison of current maps with succeeding imagery at intervals of perhaps a year or so. In the forest and open areas we hoped to determine individual species groupings.

Data Sources

ERTS-1 scene 1028-15295, taken August 20, 1972, was used to study both sites. There was a significant amount of cloud cover in this scene, which was to cause considerable trouble in the investigation. An image of a better scene, 1046-15295 from September 7, 1972, was available; however, computer compatible tapes were not received during the time of the investigation. Verification of the ERTS-derived maps was obtained from U2 flight 72-094, flown on June 7, 1972. Both test areas are on this flight line, and the photography over the areas is excellent and relatively cloud-free. Photography from sensor 14, false color infrared, was the most useful, providing the maximum amount of information on vegetation. Frame numbers 155-158 covered the Kinzua area, and frames 161-163 covered the East Branch area. Stereographic viewing was provided by the Bausch & Lomb Zoom 70 stereoscope in the ORSER laboratory.

Methodology and Analysis

Supervised, unsupervised and partially supervised approaches to the investigation were attempted. The partially supervised approach proved to be by far the most fruitful, and is recommended for study of scenes in which there are many shadows and numerous targets with varied characteristics.

Supervised Mapping

The initial approach was to use the NMAP-UMAP-training areas-STATS-DCLASS sequence of computer programs in the ORSER library[1]. The Kinzua area was chosen first, as it had larger patches of open vegetation than the East Branch area. It was hoped that these targets would yield a larger number of data points per training area, and hence result in a more statistically valid analysis. The first run of NMAP revealed an immediate problem with clouds. In spite of numerous adjustments of parameters, only the reservoir, the holding pond, and cloud shadows, could be registered. Comparison with the U2 photography revealed that not a single open vegetative area had been mapped. The terrain is hilly, and the 9:30 AM sun angle creates a very complicated light and shadow pattern. Superposition of the further complicating pattern of numerous clouds and cloud shadows made interpretation of the NMAP output virtually impossible. The UMAP program was next run on the area. Sufficient patterns could be identified on this map to reveal that an area of converging road and vegetation patterns (seen on the U2 photographs), which

[1] See ORSER Technical Report 10-73 for program descriptions.

could give a number of excellent training targets, was under clouds in the ERTS scene. At this point the East Branch area was considered for study.

Initial work with the Kinzua area had given some indication of the parameters to use for an NMAP run of the East Branch area. However, even with further "fine tuning" of the parameters, only gross features were registered. A very few open areas did seem to be mapped. A run of UMAP revealed that two scan lines were out of register (scan lines 263 and 264). (As the corresponding lines on the adjoining tape are in registry, this is probably an error in processing.) Again, very few uniform areas (with the exception of water) were mapped in this hilly terrain. In spite of these poor results, it was decided to make an attempt to establish training areas for the STATS program. The output maps from UMAP and NMAP were superimposed on a light table, and sites which had the greatest probability of being open vegetative areas were outlined. These sites were not very large, averaging 10 to 20 acres.

The output from the STATS program and the first DCLASS map revealed two interesting things. First of all, none of the areas mapped corresponded with an open area shown on the U2 photograph. Secondly, eight signatures had reasonably good histograms, indicating that each was a valid signature for a yet-to-be-determined feature. (It was later revealed that these signatures were related to large targets, such as forested areas, the reservoir, and creek vegetation). The first DCLASS map, using all 16 signatures from the first STATS run, each with a separate symbol, proved impossible to read. Reduction of the number of symbols and changing the critical distances did not significantly improve the output. Finally, using water, cloud, creek, and cloud shadow symbols (categories 4, 5, 9, 6, and 18, respectively, on Table 1) as reference, each of the other symbols was mapped individually on a series of DCLASS outputs. Spatial orientation was then possible and new training areas were defined for STATS. The second run of STATS with the newly defined signatures again revealed a good set of histograms for the areas previously yielding good signatures. However, there were no new useable signatures. A run of DCLASS revealed that no additional discernible pattern or group could be mapped, and known open areas were mapped by several symbols.

Table 1: Signatures Developed During Supervised and Unsupervised Mapping of the East Branch Area

Category Number	Category Name	Symbol	Signatures: Channel 4	Channel 5	Channel 6	Channel 7
1	NW CREEK	-	18.60	11.40	42.87	29.20
2	NW 1	-	19.00	12.72	45.94	30.56
3	NW 2	-	19.04	10.92	44.75	29.58
4	WATER	+	24.20	12.43	7.13	1.20
5	CLOUD	C	52.08	48.33	68.58	37.00
6	SHADOW 1	S	14.82	6.64	12.41	5.79
7	NW TOP	-	18.65	11.08	46.13	31.01
8	SE 1	=	19.32	11.63	51.11	34.38
9	CREEK	*	19.65	11.90	40.29	25.35
10	OPEN A	O	22.44	14.11	41.11	24.56
11	SE 2	=	20.38	12.42	57.96	38.69
12	THIN 1	T	22.40	14.80	48.60	27.80
13	THIN 2	T	23.40	14.90	58.65	36.30
14	HEMLOCK 2	#	17.87	10.25	29.37	16.87
15	THIN 3	T	25.50	19.00	54.00	33.00
16	HEMLOCK 1	#	19.00	11.50	30.00	16.50
17	CLOUD 1	C	31.00	24.00	58.50	35.50
18	SHADOW 2	S	15.60	6.93	17.13	9.00
19	CLOUD 2	C	35.60	30.40	60.80	38.20
20	CLOUD 3	C	39.67	34.67	63.00	39.33
21	CLOUD 4	C	45.00	40.00	66.00	38.50
22	CLOUD 5	C	32.29	24.71	57.14	35.71
23	CLOUD 6	C	27.67	21.67	54.67	35.67
24	CLOUD 7	C	30.00	22.64	57.82	36.36
25	OPEN B	@	25.04	16.08	69.32	43.00

All suspected forest signatures (categories 1, 2, 3, 7, 8, and 11) were then mapped individually and the maps superimposed on a light table. The areas were found to lie parallel and right next to one another. Inspection of the signatures in channel 6 revealed that their values were in ascending order, left to right on the map, and then repeated themselves. It was apparent that the signatures went from the creek, up the northwest aspect of a hill, over the hill, and down the southeast aspect to another creek or valley. This traverse encompassed a total of six signatures shown by two symbols. The names and symbols of these signatures were then changed, using one symbol for the northwest aspect, and another for the southeast aspect, to give a spatial comparison with the U2 photography. A rerun of the map with these categories is shown in Figure 1, on which an example of the mapped aspects has been delineated. (The area mapped in Figure 1 is the northeast corner of the portion of the study area shown on the U2 photograph in Figure 2). If an open area on the U2 photograph is on the northwest aspect of a hill, the symbol for that aspect would be expected to be mixed with the symbol for the open area. It is unknown, at this stage of the investigation, how much of the difference in reflectance with aspect is a function of shadow and how much is due to vegetation differences with hill aspect. The U2 photographs show a similar pattern but they are also affected by sun shadow. Creek vegetation is, however, definitely different from that found on the hills. Low altitude photography or a visit to the area will eventually be needed.

The successful mapping of hills and creeks at this stage, made it possible to precisely locate areas within the test site. However, not a single open vegetative area had yet been mapped. It was apparent that the supervised mapping procedure was not suitable for a study area of this type. The technique is useful for relatively large uniform areas, where large number of data points of the same spectral characteristics are grouped together. However, it is of very limited usefulness for small areas consisting of very few data points, where most of these points lie near the interface between the training area and contrasting areas around it. This confusion is compounded by the native inhomogeneity of training targets, such as open areas containing varied vegetation patterns.

Figure 1 : DCLASS map of hill aspects in a portion of the East Branch area. Symbols for CREEK, SHADOW, and CLOUD were mapped for reference.

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Figure 2: Black and white enlargement of U2 photograph of a portion of the East Branch area. (Flight 72-094, sensor 14, frame 72009; approximate scale:

Unsupervised and Partially Supervised Mapping

The unsatisfactory results from the investigation described above led to the use of the DCLUS program, which develops its own set of spectral signatures, using a clustering algorithm, and outputs a map on the basis of these. The initial run, of a relatively large area, yielded the three forest signatures originally obtained from STATS. However, there was still considerable confusion registered in small areas. It was then decided to "partially supervise" the DCLUS program, by working with very small areas known to be the open areas of vegetation sought. The first such open site was on the northwest aspect of a hill. The area was not homogenous; it had some patches of almost bare ground surrounding a row of what appeared on the U2 photograph to be coniferous trees. The OPEN A signature (category 10) came from this run, but a signature for the trees was not obtained. That signature (HEMLOCK 1, category 16) came from running DCLUS on an area of trees tentatively identified as hemlocks. These two signatures and their critical distances derived from DCLUS, were added to the signatures judged to be good from the earlier STATS run. Using the default critical distance of 10, this set of signatures (categories 1 through 11, 16, and 18 on Table 1) was input to the DCLASS program. The resulting map, shown on Figure 3, shows the OPEN A training area, labelled "A." It can be seen that the row of trees is effectively mapped with #'s derived from area B. Also within area A are -'s, indicating the site is located on the northwest aspect of the hill. Note also that category 10 (OPEN A) did an excellent job of mapping a road on the opposite side of the creek (compare to the photograph in Figure 2).

A distinct advantage to using the DCLUS program is that, in addition to obtaining a signature, the optimum critical distance can be determined by watching the change in symbol clustering with changes in critical distance. This feature has proven invaluable in mapping small areas. If the critical distance becomes too small, the whole target, except for one or two points, may suddenly disappear. This is probably due to "edge" effects on the signatures, causing the elements near the interface with adjacent areas to disappear when the critical distance is too small. If the critical distance is too large, the symbols scatter all over the map on both large and small targets.

Figure 3: DCLASS map of the East Branch area, combining eleven STATS and two DCLUS signatures. Outlined areas are discussed in the text.

Frequently, in using DCLUS for small targets, a signature on a fairly small block may not classify, regardless of the critical distance used. In this case, there are three procedural options:

1. Increase the number of sample points and leave the size of the block the same. In this case, the number of mapping symbols and categories must also be increased.

2. Decrease the size of the block and keep the number of categories and symbols as they were. This seems to be a better alternative than the one above. Of course, the location on the map must be known precisely to use very small blocks. Often the choice of a relatively large preliminary block (four to five times the size of the intended target area) will serve to locate the target block. An additional advantage to decreasing the size of the target block is the reduction in computer time used in multiple runs, to determine the proper critical distance.

3. Decrease the size of the block and increase the number of mapping symbols and categories. This option has not yet been found necessary.

Having determined a working methodology for obtaining signatures from DCLUS on the study area, additional signatures were defined. A rerun of DCLUS on two blank areas, thought to be clouds, proved interesting. One of these (area C on Figure 3) gave seven distinct signatures (categories 17, and 19 through 24), which were added to the cloud signatures determined earlier. These were easy to differentiate from vegetation, as they had much higher reflectance values in channel 5 and 6 than did vegetation. The second blank target (area D) was, however, definitely not a cloud. It had previously not been classified due to a very high reflectance value in channel 6. Comparison with the U2 image (see Figure 2) showed this to be an area which looked as if it had been clear cut and is now regenerating. This signature was assigned the name of OPEN B (category 25). THIN 1 and THIN 2 (categories 12 and 13 on Table 1) were obtained from a patch of thin vegetation that runs up and over a hill. The large distance of separation between these two signatures is most likely a function of shadows caused by the sun angle. THIN 4 (category 15) came from the same area, using a different critical distance. These three signatures, used as a group, seemed to map areas of thin vegetation with considerable accuracy. A map using all the current signatures was then run (Figure 4). The training area for the THIN signatures came from area E shown on this map.

Preliminary Results and Conclusions With Plans for Further Investigation

Figure 4 , the DCLASS map obtained at the time of this report, reveals several interesting features. Areas D and F, for instance, have clearly different characteristics, both on the ERTS scene and on the U2 photograph. More vegetation is present in D than in F, in fact, D seems to have a signature unique for this study area. By comparison, a considerable amount of what looks like bare soil seems to be evident in area F. This map also demonstrates that there still is some confusion between the THIN signatures and some clearly OPEN targets. Area F was not on the map from which the THIN signatures were developed, and the next task is to use DCLUS to develop one or more signatures and critical distances for this relatively large open area.

Another open area, G, just below D, further indicates the need to refine the THIN signatures to distinguish between THIN and OPEN areas. Area G is spatially well defined on the U2 photograph to be two separate areas, the lefthand portion being on a ridge and the righthand partially in a small valley, with a small forested southeast-aspect hillside between them. Spectrally, both areas are quite mottled. The map bears this out, assigning some forest symbols between the portion on the ridge to the left and the portion in the valley to the right. It is interesting to note the rather small distances of separation that these open areas, currently mapping as THIN, will have among themselves; and between themselves and the new signatures, once they have been classified by DCLUS. The greatest distance of separation between any two of the present THIN signatures is 13.2 (see Table 1), and most of this difference is quite likely due to shadow. It is anticipated that very small critical distances will have to be used to properly separate and classify these signatures. An area north of those shown in Figure 4 was largely left

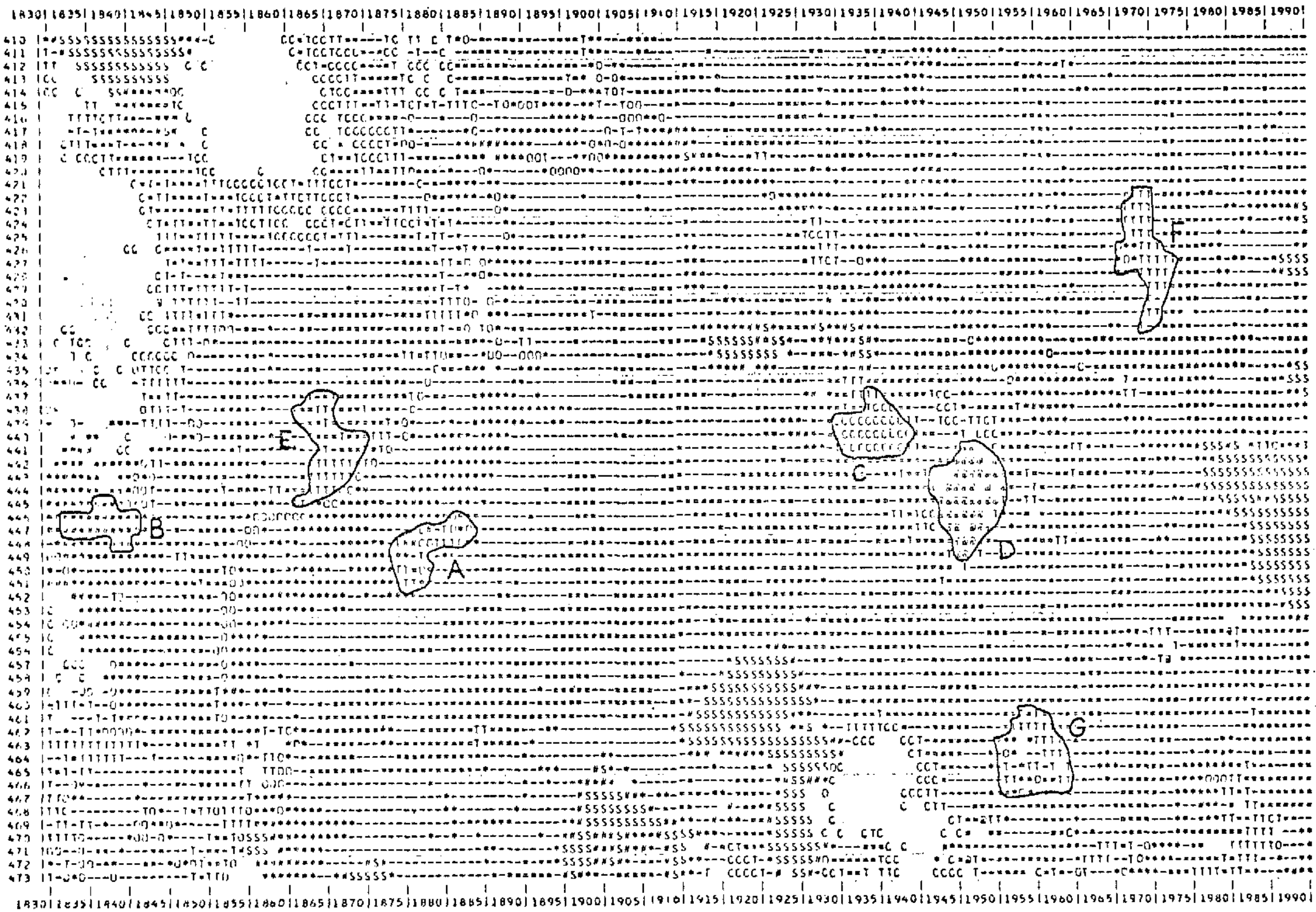

Figure 4 : DCLASS map of all signatures shown on Table . Outlined areas are discussed in the text.

blank on the map, indicating that it could not be classified with the signatures used. This is a cutover area on a plateau, entirely surrounded by a combination of OPEN, FOREST, and THIN signatures on the map. DCLUS will be used to get signatures and critical distances for the unclassified parts of this area.

The following steps are planned in continuing this research:

1. A very complex little valley to the south and west of the East Branch site has been chosen. It is planned to use the current signatures to map this area to see how well they classify closely bunched targets.

2. An attempt will be made to distinguish between various type of open cover. It has proven possible to distinguish between conifers and deciduous trees when one is predominant in an area, but it may be possible, with further refinement of signatures, to determine two different height classes and to identify them from their spectral differences. It is possible that merging summer and late fall scenes will facilitate differentiation between deciduous and conifer vegetation, due to the difference in spectral response of deciduous growth in two seasons.

3. Signatures developed and refined on the East Branch site will be used in an attempt to map the Kinzua area. This area is very similar in vegetation and terrain to that of the East Branch and the refinement of signatures obtained on cloud and supposed-cloud areas in the East Branch site should considerably clarify the mapping of the Kinzua area.

4. It is planned to use the more sophisticated classifiers, such as the RATIO and CANAL programs. The CANAL classifier requires more statistical information than the channel means provided by the DCLUS program. Therefore, DCLASS maps using DCLUS signatures will be used, instead of maps generated by UMAP, in an attempt to specify training areas for the STATS program. If this technique is successful, we will be able to use a DCLUS-DCLASS-STATS sequence of programs to generate comprehensive statistics for small training areas.

5. It is becoming quite evident that further refinement of the signatures for these areas will rapidly lead to a need for underflight photography of a larger scale than that provided by the U2

aircraft. Subtle differences, such as those we hope to determine in areas currently mapped as THIN are not discernable on U2 photographs, and these photographs suffer from some of the same shadow difficulties as the ERTS scenes. It will be highly desirable to obtain low-altitude underflight photography at an early date.

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The Pennsylvania State University
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